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WATER DISPLACING PAINT (WDP) OPTIMIZATION AND FIELD
EVALUATION(U) NAVAL AIR DEVELOPMENT CENTER WARMINSTER
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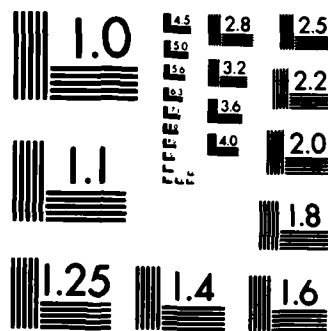
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WATER DISPLACING PAINT (WDP) OPTIMIZATION
AND FIELD EVALUATION

Charles R. Hegedus and Robert Camilletti
Aircraft and Crew Systems Technology Directorate
NAVAL AIR DEVELOPMENT CENTER
Warminster, Pennsylvania 18974

28 SEPTEMBER 1982

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Work Unit ZM501

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Washington, D.C. 20361

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A previously developed, water displacing paint has been reformulated to obtain improved pigment dispersion and a lusterless finish for camouflage purposes. The coating has exhibited durability and corrosion protection in outdoor exposure tests. Fleet evaluations by several squadrons have demonstrated its effectiveness for touch-up under high humidity conditions. It is also reported to be convenient and easy to use.		

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I N T R O D U C T I O N

A previous report, reference (a), describes the development and physical properties of a water displacing paint (WDP). This paint was developed to be used as a touch-up coating for aircraft where existing paint has cracked or chipped. Upon application, it will displace water from a metal substrate and subsequently perform as a corrosion preventive coating.

Additional evaluation of WDP following the initial report revealed two deficiencies. First, the pigment settled and compacted during storage, making re-dispersion difficult. Second, lusterless coatings were not as effective at displacing water as glossy coatings.

This report discusses:

1. Maintaining pigment dispersion during storage.
2. Developing a lusterless water displacing paint.
3. Results of outdoor exposure and field evaluations.

This effort was funded under AIRTASK WF61542001, Work Unit Number ZM501.

E X P E R I M E N T A L P R O C E D U R E S

The most effective means of maintaining pigment dispersion in WDP is to use a commercially available, anti-settling agent. After screening several products, the most effective agent was determined to be an amorphous silica, Aerosil R-972, manufactured by Degussa Inc.

Synthetic silica extender pigments with oil absorptions (ASTM D281-31, reference (b)) ranging from 140 to 180 pounds per 100 pounds of linseed oil were found to decrease the 60 and 85 degree gloss effectively. One such product is Syloid 74 manufactured by W. R. Grace and Company.

A coating optimization effort was designed to determine the concentration of the ingredients, including the above additives, necessary to maintain the original properties and to obtain a lusterless coating with adequate pigment dispersion. This effort utilized the pigment settling, water displacement, and reflectance tests described later in this section. Using the designed formulation effort and the results from these tests, an optimum formulation (Table I) was obtained. The optimum mixing procedure is described in Appendix A.

The instability of the pigment dispersion of WDP was attributed to pigment settling and compaction, possibly resulting in particle agglomeration. Two tests were performed to evaluate this deficiency; a storage stability test and an accelerated pigment settling test.

TABLE I. REFORMULATED WATER DISPLACING
PAINT (FLAT WHITE)

	<u>Parts by Weight</u>
Silicone Alkyd Resin ^a	36.3
Ethyl Acetate	18.1
Aromatic Mineral Spirits ^b	10.8
1,1,1 Trichlorotrifluoroethane	7.1
Rutile Titanium Dioxide	10.3
Zinc Molybdate	6.0
Isopropyl, Tri (N-ethylamino-ethylamino) Titanate ^c (4.5% in isopropyl alcohol) ^d	2.1
Amorphous silica	0.8
Sodium Petroleum Sulfonate ^e	2.1
Synthetic Silica	<u>6.4</u>
	100.0

- a. McCloskey Varnish Co. (385-50E)
- b. Union Oil of California (Amsco Solvent G)
- c. Kenrich Chemicals (KR-44S)
- d. Degussa Inc. (Aerosil R-972)
- e. Alox Corp. (ALOX 904)
- f. W. R. Grace and Co. (Syloid 74)

STORAGE STABILITY TEST

The storage stability test was performed in accordance with ASTM D-869, reference (c). A thoroughly mixed 470 milliliter sample of WDP was placed in a clear glass jar and stored under ambient laboratory conditions for 120 days. The paint was evaluated for pigment condition at intervals of 1, 2, 4, 7, 14, 21, 30, 60, 90, and 120 days, both visually and physically by penetrating the pigment sediment layer with a glass stirring rod to determine the condition of the pigment. The extent of pigment settling was evaluated according to the system presented in Table II.

ACCELERATED PIGMENT SETTLING TEST

A thoroughly mixed 50 milliliter sample of WDP was placed in a tube and centrifuged at 750 rotations per minute for two one-hour periods per day for four days. The amount of settling normally produced by this conditioning treatment approximates that observed after one year of storage, reference (d). The paint was then examined for pigment condition according to Table II. After the evaluation, the tube was agitated vigorously by hand for 60 seconds. Subsequently, the coating was again examined for pigment condition to determine the ease of pigment re-dispersion.

TABLE II. EVALUATION STANDARDS FOR THE STORAGE STABILITY TEST (REFERENCE b)

10	No change from original.
08	No significant resistance to sidewise movement with spatula. Slight deposit clings to spatula.
06	Spatula descends through settlings under its own weight. Definite resistance to sidewise movement of spatula. Portions of sediment layer cling to spatula.
04	Spatula does not descend through sediment under its own weight. Difficult to move spatula sidewise. Slight resistance to edgewise movements. Uniform suspension easily restored with spatula.
02	Very high resistance to sidewise movement of spatula. Definite resistance to edgewise movement. Uniform suspension can still be restored.
00	Very firm sediment layer, not restorable to a uniform suspension by manual stirring with spatula, even after supernatant liquid is poured off.

WATER DISPLACEMENT TEST

Steel test specimens conforming to AISI 1010 of MIL-S-7952 with dimensions of 2 x 4 x 0.125 inches (50 x 101 x 3.18 mm) were used in this test.

Duplicate test panels were inclined at a 30° angle from the horizontal by raising one of the two-inch ends. The panels were liberally sprayed with red-dyed synthetic sea water* so that fine droplets completely covered the panels. Subsequent to the water application, one milliliter of the paint was poured along the upper edge of the specimens using a pipette. After being suspended vertically for one minute, the panels were placed horizontally, painted side up, in a closed desiccator at 70±5°F (21±3°C) and 100% static relative humidity.

After four hours in the desiccator, the painted surfaces of the specimens were examined for possible water entrapment. The coating was then removed from the panels by wiping with a cloth dampened with methyl ethyl ketone. The bare steel was examined for signs of corrosion caused by residual synthetic sea water on the surface.

* Synthetic sea water solution: 50 grams of sodium chloride, 22 grams of magnesium chloride, 3.2 grams of calcium chloride, and 8.0 grams of sodium sulfate in 1.0 liter of distilled water.

GLOSS

Gloss measurements of 60 and 85 degrees were obtained according to ASTM method D 523, reference (e). The test was performed using a GG-7562 multi-angle glossmeter manufactured by Gardner Laboratory.

GONIOPHOTOMETRY MEASUREMENTS

The visual directional reflectance of the applied coatings was measured using a GG-9200 goniophotometer manufactured by Gardner Laboratory. The goniophotometer measures reflectance as a function of both the angle of illumination and the angle of detection. The measurements were obtained according to ASTM method E167 (reference (f)) by varying the angle of illumination with the angle of detection at 45 degrees.

ATMOSPHERIC EXPOSURE TESTS

WDP was applied to 3 x 6 x 0.020 inch (7.6 x 15.2 x 0.05 cm) 2024-T3 bare aluminum alloy specimens. The specimens were cleaned and treated with materials conforming to Military Specification MIL-C-81706 to produce a chemical conversion coating conforming to MIL-C-5541. After seven days, the specimens were scribed through the coating exposing the aluminum substrate. Several panels were then exposed on the USS CONSTELLATION for eight months. These shipboard exposure tests are described and discussed in detail in reference (g).

Similar specimens were exposed in a rural environment of the Netherlands for 15 months. The pH of the rain water in the Netherlands is less than 4, a condition commonly referred to as "acid rain." This is due to the high sulfur dioxide content in the atmosphere.

FIELD EVALUATIONS

Aerosol cans of WDP were forwarded to several U. S. Navy aircraft squadrons along with performance evaluation forms. The squadrons were of various aircraft deployed in a wide variety of environments. (See Appendix B) The maintenance crews were instructed to complete the form in detail when using and evaluating WDP.

EXPERIMENTAL RESULTS

The results of the storage stability test are listed in Table III. These results indicate a slight improvement in the settling problem using an anti-settling agent.

The results of the accelerated pigment settling test are listed in Table IV. Again, an improvement in pigment settling is observed when an anti-settling agent is used.

It should be noted that, although the pigment settles in the container, it is easily redispersed using an automatic paint container similar to a Red Devil paint shaker. A problem is encountered, however, when the coating is in an aerosol can. Aerosols are usually agitated by hand. In the laboratory, it has been confirmed that paint in aerosol containers can be properly mixed if shaken rapidly for several minutes, either by hand or preferably on an automatic paint conditioner.

TABLE III. STORAGE STABILITY TEST RESULTS

<u>Inspection Period (Days)</u>	<u>Pigment Condition (See Table II)</u>	
	<u>WDP</u>	<u>Reformulated WDP</u>
1	10	10
2	10	10
4	10	10
7	10	10
14	08	10
21	06	08
30	02	04
60	00	02
90	00	02
120	00	02

TABLE IV. ACCELERATED PIGMENT SETTLING TEST RESULTS

<u>After Centrifugation</u>		
<u>Sample</u>	<u>Pigment Condition</u>	<u>Observation</u>
WDP	00	3 distinct layers
Reformulated WDP	04	3 layers with no distinct separation lines
<u>After Agitation</u>		
<u>Sample</u>	<u>Pigment Condition</u>	<u>Observation</u>
WDP	00	2 distinct layers
Reformulated WDP	08	uniform suspension

The 60 degree gloss of the lusterless version of WDP is 2.0 percent and the 85 degree gloss is 3.1 percent. Specification requirements are for a maximum of 3 and 5% respectively.

Figure 1 is a graph of the directional reflectance of both the gloss and lusterless versions of WDP. The graph of the lusterless coating is smooth around the hemisphere with no outstanding peaks indicating a uniform reflectance. The graph of the gloss coating has a peak at 45 degrees. This is expected because 45 degrees is the gloss angle with this geometry, and a gloss coating should exhibit a significant increase in reflectance at that angle.

The reformulated WDP was tested for water displacing ability and compared to the results obtained using the previous formulation. Immediately following the application of WDP onto the specimen, the coating was uniform with no indication of water remaining on the specimen. After the four-hour period, the specimen exhibited no corrosion demonstrating the effectiveness of WDP as a water displacing agent.

After completion of the eight months exposure period on the aircraft carrier the specimens exhibited minimal substrate corrosion in and along the scribe and no substrate corrosion in the unscribed area. Figure 2 illustrates these results. The specimens exposed in the Netherlands for 15 months exhibited minimal corrosion in and along the scribe and no corrosion in unscribed areas (Figure 3). The specimens are displayed as removed from exposure conditions, after cleaning with a mild detergent, and after removal of the WDP coating with a chemical paint stripper.

F I E L D E V A L U A T I O N S

Appendix B contain several completed forms which are representative of the returned evaluation questionnaires from the fleet.

In general, WDP was found to be effective, durable, and convenient to use.

C O N C L U S I O N S

1. A lusterless paint has been developed which will displace water from a metal surface upon application.
2. The paint can be applied by aerosol or conventional air spray.
3. The water displacing paint has exhibited durability in naval aircraft environments and has performed well in preliminary field evaluations.

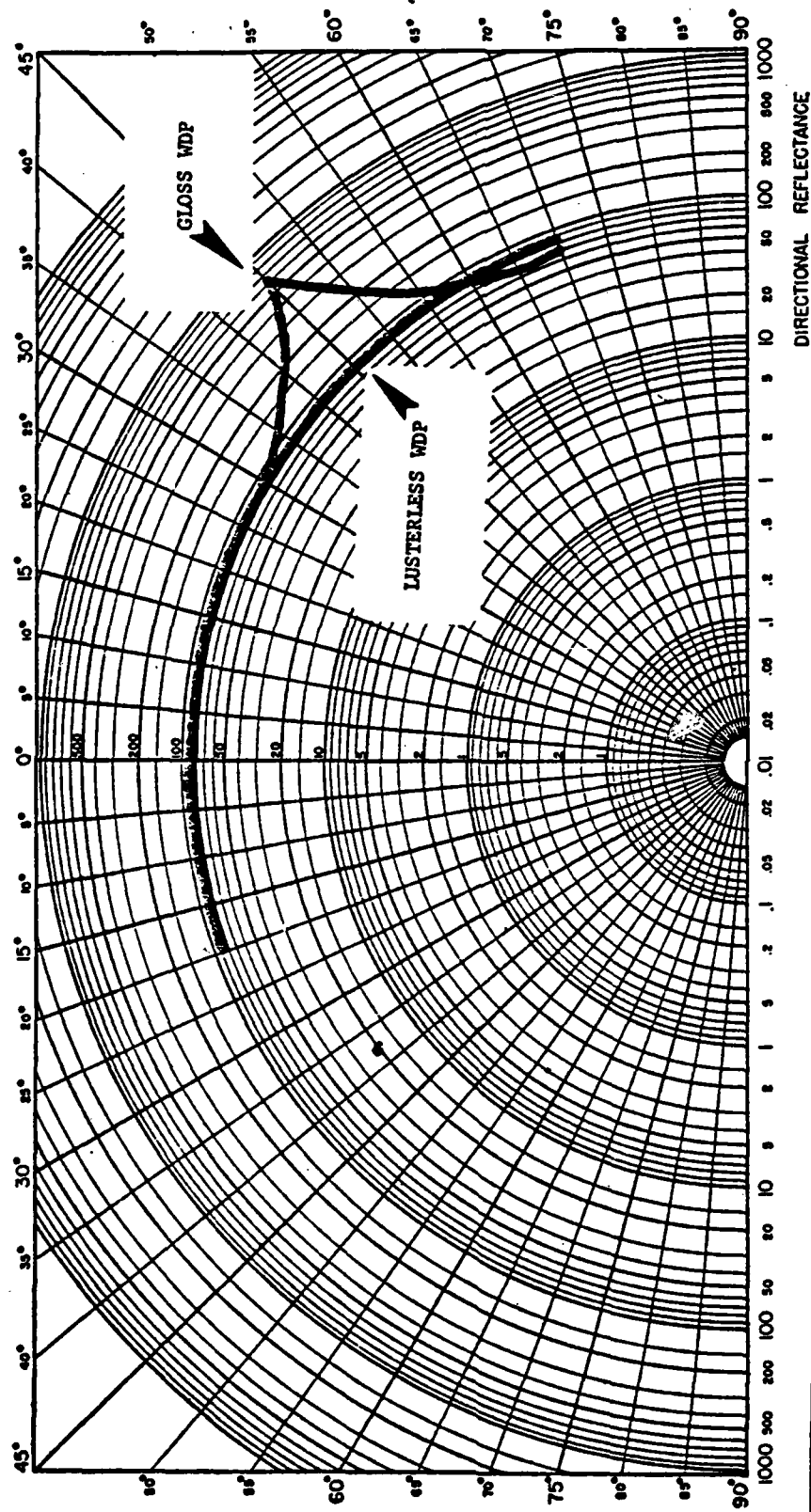
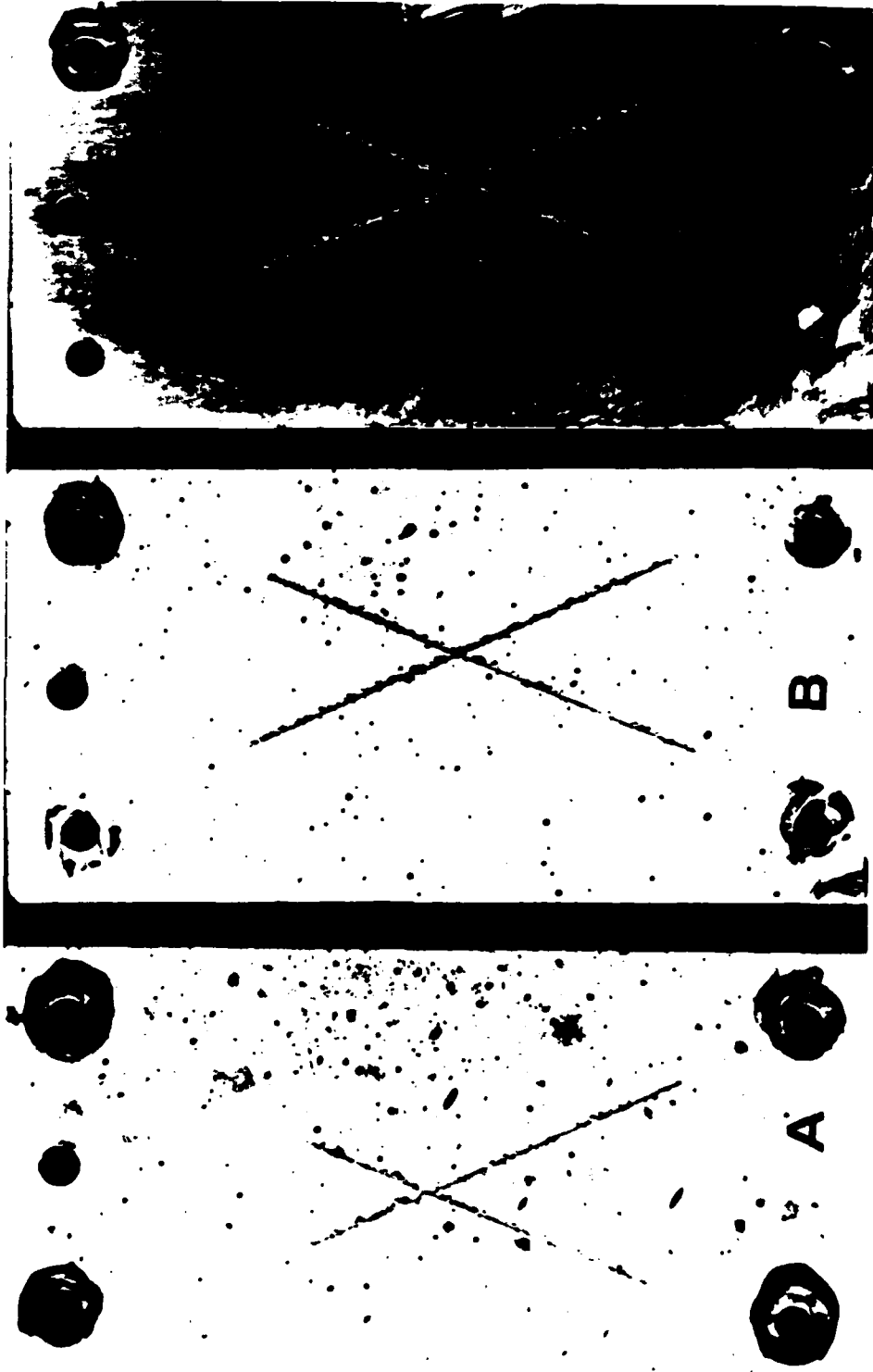


FIGURE 1. GONIOPHOTOMETRIC RESULTS OF GLOSS AND LUSTERLESS WATER DISPLACING PAINT

WATER DISPLACING PAINT (WDP) EXPOSURE PANELS FROM U.S.S. CONSTELLATION

AFTER 8 MONTHS EXPOSURE



AS REMOVED

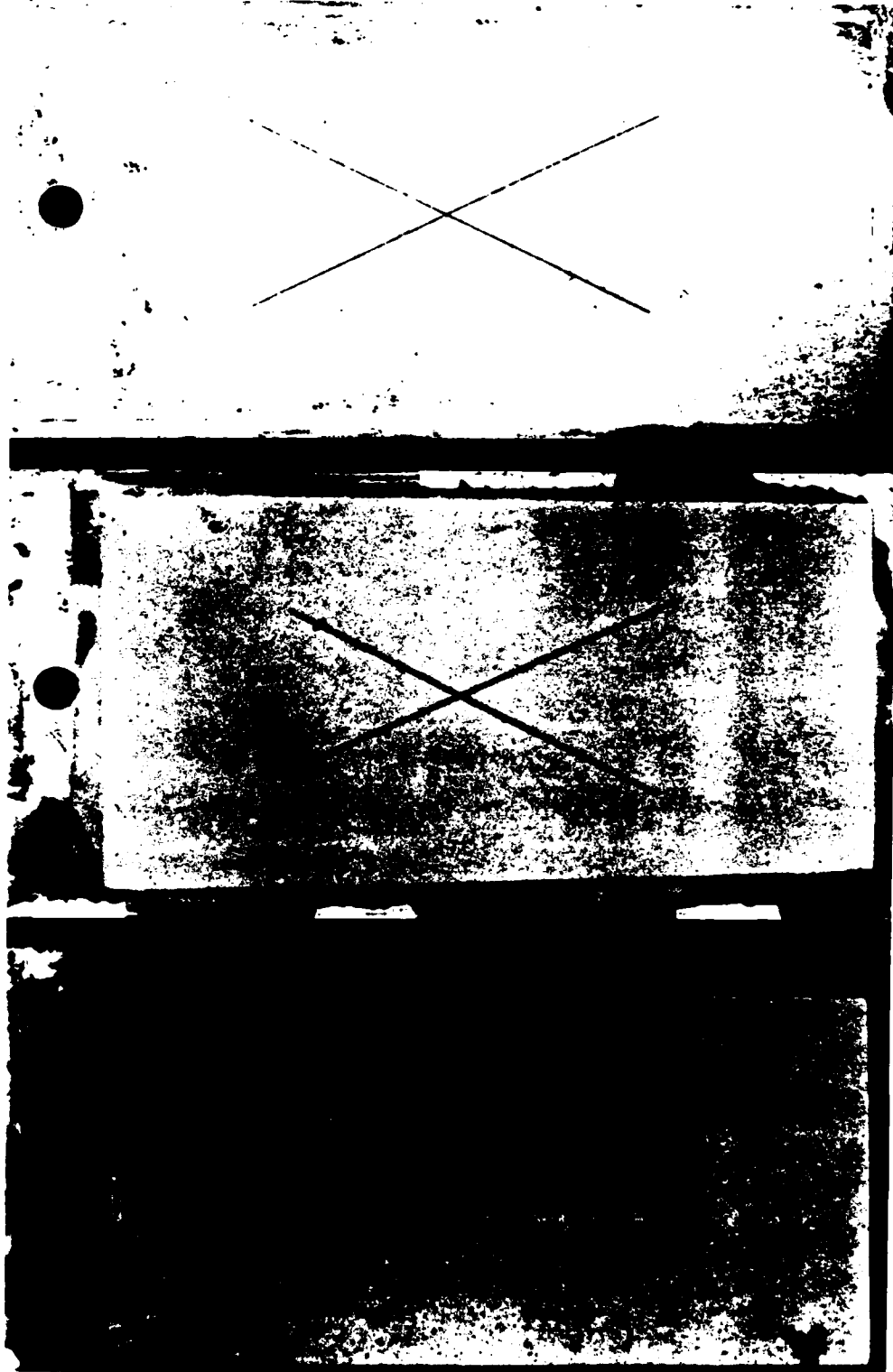
DETERGENT CLEANED

AFTER WDP REMOVAL

NOTE: DARK SPOTS ON PANEL B- ACCIDENTAL PAINT SPLATTERED DURING EXPOSURE PERIOD

FIGURE 2 U.S.S. CONSTELLATION EXPOSURE SPECIMENS

WATER DISPLACING PAINT (WDP) EXPOSURE PANELS
15 MONTHS OUTDOOR EXPOSURE IN THE NETHERLANDS



AFTER WDP REMOVAL

DETERGENT CLEANED

AS REMOVED

FIGURE 3 NETHERLANDS EXPOSURE SPECIMENS

R E F E R E N C E S

- (a) C. R. Hegedus, The Development of a Water Displacing, Touch-up Paint, Report No. NADC-80207-60, Naval Air Development Center, Warminster, PA February 1981.
- (b) ASTM D281-31, Oil Absorption of Pigments by Spatula Rub-Out.
- (c) ASTM D869, Standard Method of Test for Evaluating Degree of Settling of Traffic Paint
- (d) G. G. Sword, Paint Testing Manual, ASTM STP 500, American Society for Testing and Materials, Philadelphia, PA, 1972, p. 170.
- (e) ASTM D523, Standard Test Method for Specular Gloss.
- (f) ASTM E167, Standard Recommended Practice for Goniophotometry of Reflecting Objects and Materials.
- (g) E. J. Jankowsky and S. J. Ketcham, Shipboard Exposure Testing, Report No. NADC-81075-60, Naval Air Development Center, Warminster, PA, September 1981.

A C K N O W L E D G E M E N T

The authors wish to thank Dr. R. J. H. Wanhill of the National Aerospace Laboratory, the Netherlands for his assistance in the WDP exposure tests.

A P P E N D I X A

MIXING PROCEDURE FOR WATER DISPLACING PAINT

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MIXING PROCEDURE FOR WATER DISPLACING PAINT

1. In the following order, mix ethyl acetate, mineral spirits, and trichlorotrifluoroethane while stirring.
2. Add the silicone alkyd resin to the solvent mixture and stir until the resin is completely dissolved.
3. Add the titanate coupling agent and stir for five minutes.
4. Place the solution in a ball mill with the titanium dioxide and zinc molybdate and mill to a 6 to 7 Hegman grind.
5. Add Aerosil R-972 and mill for 30 minutes.
6. Add Alox 904 and mill for 30 minutes.
7. Finally add Syloid 74 and mill for 30 minutes.

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Aircraft and Crew Systems Technology Directorate
Warminster, Pennsylvania 18974

6062

EXPERIMENTAL WATER DISPLACING PAINT EVALUATION SHEET (WDP)

Batch No. 5 (16440 LIGHT GRAY)

TYPE AIRCRAFT: A-4M

AREAS TO WHICH WDP WAS APPLIED: all over the Aircraft

SURFACE PREPARATION PROCEDURES, IF ANY, PRIOR TO APPLICATION OF WDP:

Yes, the old paint was Rub-up-mek was to clean the surface

EASE OF APPLICATIONS: Satisfactory Unsatisfactory

If unsatisfactory, why?

GENERAL APPEARANCE: Satisfactory Unsatisfactory

If unsatisfactory, why?

NEED FOR REAPPLICATION: Yes No

If yes, why? yes on leading edge of slat and wing

EFFECTIVENESS OF WPD AS A TOUCH-UP PAINT: Excellent Good
Fair Unsatisfactory

COMMENT ON EFFECTIVENESS:

CONDITIONS DURING EXPOSURE: Humid Dry Tropical
Shipboard Land Based

WAS WDP REMOVED: Why:
COMMENTS

Signature [Signature] Title Capt Date 9-14-81

Naval Air Development Center
Aircraft and Crew Systems Technology Directorate
Warminster, Pennsylvania 18974

6062

EXPERIMENTAL WATER DISPLACING PAINT EVALUATION SHEET (WDP)Batch No. 6 WHITETYPE AIRCRAFT: A4-M

AREAS TO WHICH WDP WAS APPLIED:

SURFACE PREPARATION PROCEDURES, IF ANY, PRIOR TO APPLICATION OF WDP:

EASE OF APPLICATIONS:

Satisfactory

Unsatisfactory

If unsatisfactory, why?

GENERAL APPEARANCE:

Satisfactory

Unsatisfactory

If unsatisfactory, why?

NEED FOR REAPPLICATION:

Yes

No

If yes, why?

EFFECTIVENESS OF WPD
AS A TOUCH-UP PAINT:

Excellent

Good

Fair

Unsatisfactory

COMMENT ON EFFECTIVENESS:

CONDITIONS DURING EXPOSURE:

Humid

Dry

Tropical

Shipboard

Land BasedWAS WDP REMOVED:
COMMENTS

Why:

Signature

L.H. Reynolds

Title

CPLDate 3 Nov. 81ACTIVITY: MA211, MAG 13

B-4

NADC-82189-60

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EXPERIMENTAL WATER DISPLACING PAINT EVALUATION SHEET (WDP)

Batch No.

6 (17875, IN SIGNIA WHITE)

TYPE AIRCRAFT: A-6-E \ Tram.

AREAS TO WHICH WDP WAS APPLIED:

FUSE LAGE SECTIONS

SURFACE PREPARATION PROCEDURES, IF ANY, PRIOR TO APPLICATION OF WDP:

CLEANED AND SCUFF SAND.

EASE OF APPLICATIONS:

Satisfactory

Unsatisfactory

If unsatisfactory, why?

GENERAL APPEARANCE: Satisfactory

Unsatisfactory

If unsatisfactory, why?

EXCEPT SLIGHT DISCOLORATION
FROM NORMAL WHITE PAINT

(SEE ENCL 202134
OCT 3)

NEED FOR REAPPLICATION:

Yes

No

If yes, why?

EFFECTIVENESS OF WPD
AS A TOUCH-UP PAINT:

Excellent

Good

Fair

Unsatisfactory

COMMENT ON EFFECTIVENESS:

CONDITIONS DURING EXPOSURE:

Humid

Dry

Tropical

Shipboard

Land Based

WAS WDP REMOVED:

NO

Why:

COMMENTS

Signature

Title

NADC

of Corrosion

Date

31 SEP 8

ACTIVITY: VMA(AW)-242 MENS ELTARO CA

B-5

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Aircraft and Crew Systems Technology Directorate
Warminster, Pennsylvania 18974

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EXPERIMENTAL WATER DISPLACING PAINT EVALUATION SHEET (WDP)

Batch No. 6 (WH175)

TYPE AIRCRAFT: ACML 149792 (C-130)

AREAS TO WHICH WDP WAS APPLIED: ANT. Mount & Panels

SURFACE PREPARATION PROCEDURES, IF ANY, PRIOR TO APPLICATION OF WDP:

Strip Idone & painted

BASE OF APPLICATIONS:

Satisfactory

Unsatisfactory

If unsatisfactory, why?

GENERAL APPEARANCE:

Satisfactory

Unsatisfactory

If unsatisfactory, why?

NEED FOR REAPPLICATION:

Yes

No

If yes, why?

EFFECTIVENESS OF WDP
A TOUCH-UP PAINT:

Excellent

Good

Fair

Unsatisfactory

REMARKS ON EFFECTIVENESS:

would like to see more of it use
in the system ease to apply need
very little preparation

CONDITIONS DURING EXPOSURE:

Humid

Dry

Tropical

Shipboard

Land Based

HAS WDP REMOVED:

NO

Why:

REMARKS

Signature: Johnny Bann Title: NCOIC c/c Date: 10-30-81
Location: VMGR-352 MCAS El Toro CA

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EXPERIMENTAL WATER DISPLACING PAINT EVALUATION SHEET (WDP)

Batch No. *2*

TYPE AIRCRAFT: *EDC*

AREAS TO WHICH WDP WAS APPLIED:

Pylon
SURFACE PREPARATION PROCEDURES, IF ANY, PRIOR TO APPLICATION OF WDP:

sanded, washed

EASE OF APPLICATIONS: Satisfactory

Unsatisfactory

If unsatisfactory, why?

GENERAL APPEARANCE: Satisfactory

Unsatisfactory

If unsatisfactory, why?

NEED FOR REAPPLICATION: Yes

No

If yes, why?

EFFECTIVENESS OF WPD:

Excellent

Good

Fair

Unsatisfactory

COMMENT ON EFFECTIVENESS:

CONDITIONS DURING EXPOSURE:

Humid

Dry

Tropical

Shipboard

Land Based

ACTIVITY: *UAW 103*

Signature

David J. DeMan Title *AMS-3*

Date

4 Dec 80

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Aircraft and Crew Systems Technology Directorate
Warminster, Pennsylvania 18974

6062

EXPERIMENTAL WATER DISPLACING PAINT EVALUATION SHEET (WDP)

Batch No. 2

TYPE AIRCRAFT: E2-C

AREAS TO WHICH WDP WAS APPLIED: stbd inboard Rudder (TOP side)

SURFACE PREPARATION PROCEDURES, IF ANY, PRIOR TO APPLICATION OF WDP:

Sanded + Cleaned

EASE OF APPLICATIONS:

Satisfactory

Unsatisfactory

If unsatisfactory, why?

GENERAL APPEARANCE:

Satisfactory

Unsatisfactory

If unsatisfactory, why?

NEED FOR REAPPLICATION:

Yes

No

If yes, why?

EFFECTIVENESS OF WPD:

Excellent

Good

Fair

Unsatisfactory

COMMENT ON EFFECTIVENESS:

Very Good

CONDITIONS DURING EXPOSURE:

Humid

Dry

Tropical

Shipboard

Land Based

ACTIVITY:

VAW-125 C/C

Signature E.E. Wyath

Title AMS-2

Date 11-17-80